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Anomalous Results from PO Applied to Reflector Antennas: The Importance of Near Field Computations

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Introduction: There is no doubt among the designers of reflector antennas that the physical optics (PO) analysis technique is the most popular numerical technique. Powerful computer codes are available for the analysis of single or multi reflector antenna systems. Additionally, ever-increasingly demand on the antenna performance necessitates the computation of antenna far field patterns under various situations. For example, in using multi reflector antennas such as, Gregorian or Cassegrain, it may become necessary to determine the total fields including the feed radiation pattern, subreflector scattered pattern and the main reflector scattered pattern. In these situations, the common practice is to sum up various scattered fields and the incident field contributions to obtain the desired total field. It is the purpose of this paper to demonstrate that the typical approach based on the far field pattern of the feed would result into erroneous result and special care must be exercised to obtain the correct result. This will be demonstrated through a detailed investigation of a representative test case.

Gregorian Reflector Antenna Geometry: The configuration of the Gregorian reflector antenna is shown in Fig. 1. It is assumed that the subreflector is illuminated by a source with its far field pattern describable as COS**Q type pattern with Q=103. Our objective is to determine the total field by incorporating the contributions from the feed, subreflector and main reflector. Two scenarios will be considered.

Case (a) -- Feed Illumination on the subreflector using far fields: It is a common exercise to use the far field pattern of the feed as the illumination field on the subreflector. One then determines the PO current on the subreflector to finally provide the field on the main reflector. The total field is then obtained by adding the far field of the feed, far field scattered field of the subreflector and the far field scattered field of the main reflector. It is anticipated that if the computations are correct in the back of the subreflector and main reflector the total field levels must be low. We will show that erroneous results are obtained in this case.

Case (b) -- Feed Illumination on the subreflector using near fields: In this case, we first use the spherical wave expansion to determine the near field of the feed based on the COS**Q far field pattern. This near field is then used to illuminate the subreflector. One then determines the PO current on the subreflector to finally provide the field on the main reflector. The total field is then obtained by adding the far field of the feed, far field scattered field of the subreflector and the far field scattered field of the main reflector. As before, it is expected that if the computations are correct in the back of the subreflector and main reflector the total field levels must be low. We will show that correct results are obtained in this case.

Subreflector Total Field: In order to properly clarify why case (a) is not providing the correct result, different aspects of the total field is carefully analyzed. Fig. 2 shows the scattered field of the subreflector when illuminated by the far field pattern of the feed. The computations have been done with respect to the main reflector coordinates with the feed location used as the phase reference point. It is interesting to note that in the back of the subreflector in the direction of the feed a back-scattered field similar to the far field pattern of the feed is generated. However, as seen in Fig. 3(a) the phase is not 180 degrees out of phase with respect to the feed far field phase. This will result into the lack of proper cancellation between the feed far field and the subreflector-scattered pattern. This lack of proper cancellation (see Figure 4) will demonstrate itself as an unwanted high-level sidelobe in the overall total pattern.

Next, the situation of case (b) will be implemented. As mentioned before, one first obtains the near field of the feed for the determination of PO current on the subreflector and then computes the scattered field off the subreflector. Results are also shown in Fig. 2. Note that the amplitude far field patterns are very similar to the previous case. However, as seen in figure 3(b), the scattered phase pattern of the subreflector appears to be approximately 180 degrees out of phase with the far field phase of the feed in the back region of the subreflector. This will result in proper cancellation of these fields as shown in Figure 4.

Overall Antenna Total Field: The overall Gregorian reflector antenna total field for case (a) and (b) are shown in Figure 5. These patterns are plotted in the main reflector coordinate system. This figure clearly demonstrates the appearance of the anomalous sidelobe for case (a) for which the far field pattern of the feed was used. This exercise has clearly demonstrated that proper use of the feed near field is required to obtain the correct total fields. The level of the erroneous sidelobe depends on the feed directivity and its location with respect the subreflector.

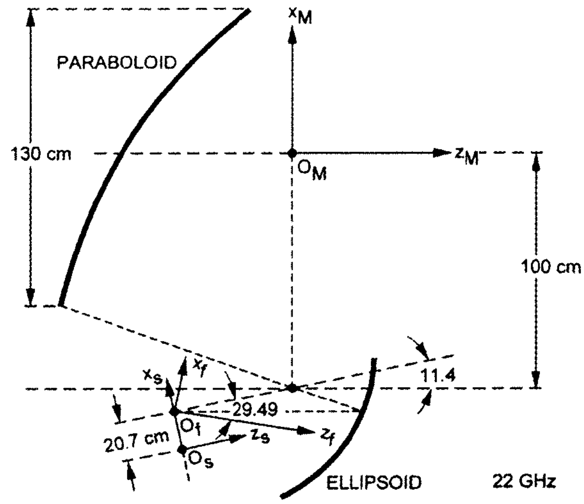

Figure 1. Geometry of the Gregorian Reflector Antenna

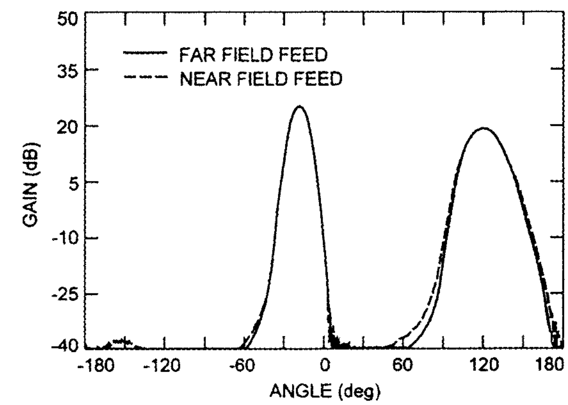

Figure 2. Subreflector Scattered Patterns in Main Reflector Coordinate System with Feed as Phase Reference Point

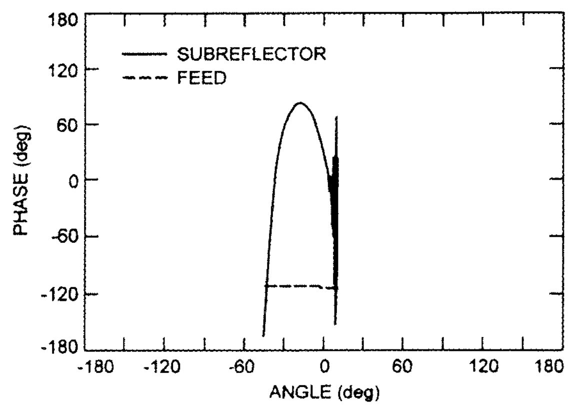

Figure 3a. Phase Patterns of Feed Far Field and Subreflector Scattered Field for Case (a)

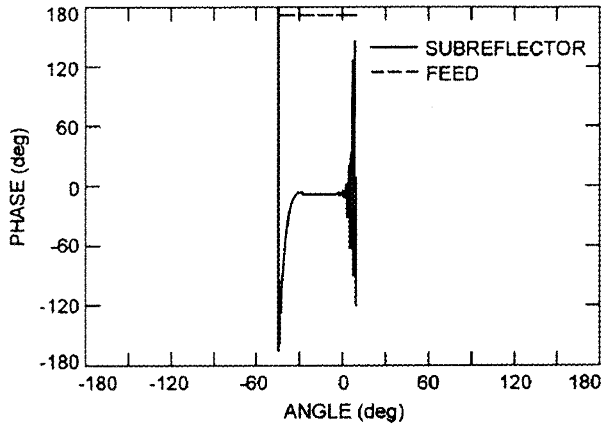

Figure 3b. Phase Patterns of Feed Far Field and Subreflector Scattered Field for Case (b)

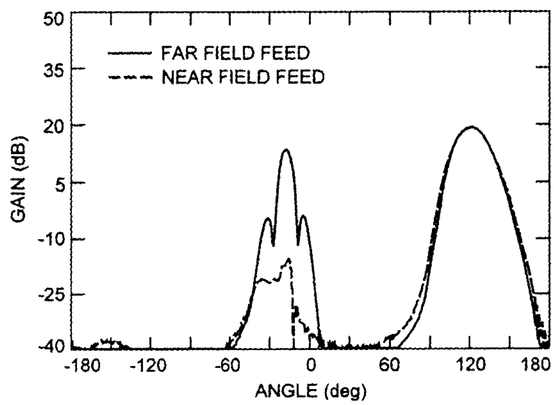

Figure 4. Subreflector Scattered Field Plus Feed Far Fields for Cases (a) and (b)

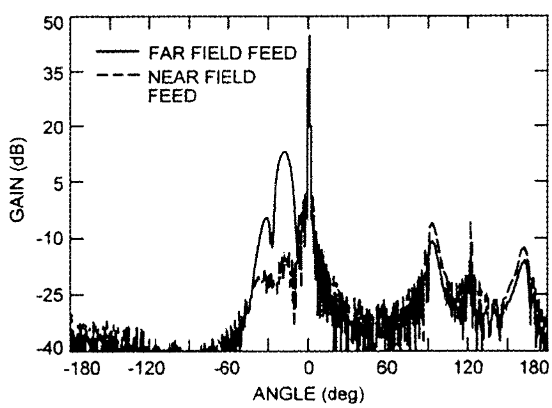

Figure 5. Total Gregorian Reflector Fields